Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Evaluation of Juvenile Fall Chinook Stranding on the Hanford Reach

Bonneville project number, if an ongoing project 9701400

Business name of agency, institution or organization requesting funding
Washington Department of Fish and Wildlife

Business acronym (if appropriate) WDFW

Proposal contact person or principal investigator:

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Subcontractors. List one subcontractor per row; to add more rows, press Alt-Insert from within this table

Organization	Mailing Address	City, ST Zip	Contact Name
USGS/BRD	National Fisheries Research Center, Columbia River Field Station	Cook, WA 98605	Matt Mesa
Streamside Programs Consultants	105 W Cherokee Dr.	Estes Park, CO 80517	C.E. Cushing
PNNL	P.O. Box 84262	Seattle, WA 98124	Dave Geist
University of Idaho	BURSAR GWK757-70013743	Moscow, ID 83844	Dave Bennett

NPPC Program Measure Number(s) which this project addresses.
Page 5-20, 5.1D.4

NMFS Biological Opinion Number(s) which this project addresses. If the project relates to the Kootenay Sturgeon Biological Opinion, the NMFS Hydro system Operations Biological Opinion, or other Endangered Species Act requirements, enter the Action Number and Biological Opinion Title.

National Marine Fisheries Service Endangered Species Act - Section 7 Biological Opinion on the Reinitiation of Consultation on 1994-1998 Operation of The Federal Columbia River Power System and Juvenile Transportation Program, Page 162 #11.

Other planning document references.
If the project type is "Watershed" (see Section 2), reference any demonstrable support from affected agencies, tribes, local watershed groups, and public and/or private landowners, and cite available documentation.

NA

Subbasin.

Hanford Reach of the Columbia River

Short description.

Evaluate effect of diel water fluctuations resulting from power peaking activities at Priest Rapids Dam on: 1) rearing juvenile fall chinook, 2) resident fish, and 3) the benthic community inhabiting the Hanford Reach of the Columbia River. Assess direct and delayed mortality and increased susceptibility to predation of juvenile chinook resulting from exposure to warm water in entrapment zones created by discharge fluctuations. Develop a GIS based juvenile chinook susceptibility model integrating detailed river bathymetry (COE-SHOALS), juvenile fall chinook habitat utilization mapping (USGS/BRD), and two flow models (USFWS-IFIM, PNNL-Unsteady Flow Model).

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
+	Resident fish	+	O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries	X	Research	+	Ecosystems
	Climate	+	Monitoring/eval.	X	Flow/survival
	Other		Resource mgt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat enhancement/restoration
			Acquisitions		

Other keywords.

modeling, hydrodynamics

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
9102900	Life History of Fall Chinook in Columbia River Basin	Shared staff, field data, modeling data, and equipment

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Evaluate effect of diel water fluctuations from power peaking activities at Priest Rapids Dam on rearing fall chinook in the Hanford Reach.	a	Continue analysis of data collected during controlled river elevation reduction tests conducted in FY98.
		b	Conduct laboratory behavioral and physiological tests at USGS/BRD CRRL to determine effect on rearing juvenile fall chinook of exposure to warm water in entrapment areas (direct and delayed mortality, reduced performance, predator susceptibility).
		c	Collect field data under normal hydro power operations throughout fall chinook emergence and rearing period (April-June 1999).
		d	Analyze/report results of field data/tests collected in 1997-99.
2	Evaluate effect of diel water fluctuations from power peaking activities at Priest Rapids Dam on resident fish in the Hanford Reach.	a	Continue analysis of data collected during controlled river elevation reduction tests conducted in FY98.
		b	Collect field data under normal project operations throughout spring 1999 period.

		c	Analyze/report results of field data/tests collected in 1997-99.
3	Evaluate effect of diel water fluctuations from power peaking activities at Priest Rapids Dam on benthic macro invertebrate community in the Hanford Reach (U of I).	a	Conduct field work under normal operating conditions at identified sampling sites. Use barbecue basket array staggered at incremental flow elevations to sample macro invertebrates exposed to various levels of dessication.
		b	Conduct laboratory analysis of macro invertebrate samples.
		c	Determine relationship between water fluctuation and macro invertebrate abundance.
		d	Write final report
4	Develop juvenile fall chinook susceptibility model.	a	Perform Scanning Hydrographic Operational Airborne Lidar (Light Detection and Ranging) Survey (SHOALS) to obtain detailed bathymetry of Hanford Reach. (Cost Share with USGS/BRD, COE performs survey).
		b	Integrate Unsteady Flow Model (PNNL), IFIM Model (USFWS), detailed micro-habitat survey information (WDFW/USGS-BRD), and SHOALS data into dynamic model of Hanford Reach. Include model fields for juvenile fall chinook emergence timing and rearing periods.

Objective schedules and costs

1	10/1998	09/1999	57
2	10/1998	09/1999	8
3	10/1998	09/1999	10
4	10/1998	09/1999	25
Total	10/1998	09/1999	100

Schedule constraints.

Controlled river elevation reduction tests are scheduled to be conducted for this evaluation April through June of 1998 (after the submittal of this proposal form). These tests are to evaluate the effect of a 50 kcfs reduction in discharge at Priest Rapids Dam on the anadromous and resident fish inhabiting the Hanford Reach downstream. This is a conservative testing protocol which has been established to minimize the impact on: A) project operations and B) the population of fish inhabiting the Hanford Reach while C) still providing meaningful results (based upon historical discharge analysis, modeling, and field work conducted in 1997). A 50 kcfs reduction in discharge will result in approximately a -3.5 vertical foot change in tailwater elevation which has ranged historically to in excess of -13 feet during the juvenile fall chinook rearing period. It is not believed at this time that more extreme controlled river elevation reduction tests will be necessary in 1999. However, the need for additional testing in 1999 will be based upon the results of 1998 tests.

Completion date.
12/31/99

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$100,000
Fringe benefits		$27,000
Supplies, materials, non-expendable property		$2,000
Operations & maintenance		$6,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		0
PIT tags	# of tags:	0
Travel		$8,000
Indirect costs		$26,000
Subcontracts		$215,000
Other		0
TOTAL		$385,000

Out year costs

Out year costs	FY2000	FY01	FY02	FY03
Total budget	$50,000	$10,000	$10,000	$10,000
O&M as % of total	20	100	100	100

Section 6. Abstract

The primary objective of this project is to assess juvenile chinook mortality on the Hanford Reach resulting from hydroelectric power generation changes. This work is

consistent with objectives identified in both the 1994 CBFWP and the BIOP and will serve to minimize fish losses resulting from hydroelectric generation activities. This evaluation began in 1997 and is scheduled to conclude in December of 1999. Direct juvenile chinook mortality was observed most often as a result of exposure to warm water in entrapment zones during the pilot year (1997). A combination of physiological and behavior tests will be conducted via subcontract by the USGS/BRD Columbia River Research Laboratory to fully assess this. Objectives 2 and 3 are to assess the effect of water fluctuations on resident fish species (2) and on the benthic community (3). The benthic evaluation will be conducted via subcontract by the University of Idaho Department of Fish and Wildlife and Streamside Program Consultants (C.E. Cushing). A juvenile chinook susceptibility model for the Hanford Reach will also be developed for this project (Objective 4) by the Pacific Northwest National Laboratories. This model will integrate four primary components from collaborating agencies. This is a cooperative study with WDFW acting as the lead agency but involving several agencies also conducting work in the Hanford Reach. Sharing of personnel, equipment, and data is and will continue to occur between collaborating agencies. The results of this evaluation are expected to yield 1) an assessment of the impact of diel water fluctuations on: A) juvenile chinook, B) resident fish, and C) the benthic community of the Hanford Reach as well as recommendations for corrective action (operational constraints). A comprehensive GIS based susceptibility model will also be created to determine the duration in which operational constraints will be imposed. This will require annual monitoring.

Section 7. Project description

a. Technical and/or scientific background.

The Hanford Reach is subject to flow manipulation from Priest Rapids Dam, where hourly flows fluctuate rapidly due to changes in hydroelectric generation (peaking), irrigation, water storage, and flood control. These rapid fluctuations in river flow are a known cause for stranding newly emerged fry on gently sloped banks and gravel bars, and the entrapment of all life stages in potholes formed by the receding water. Currently, a minimum flow restriction is maintained for the Hanford Reach during fall spawning to protect pre-emergent salmonids but flows fluctuate above the restricted level and are not managed after emergence. A minimum discharge criterion of 36,000 cfs is specified in the Federal Energy Regulatory Commission (FERC) license for the Priest Rapids project (Federal Power Commission, 1959). However, a ramping rate restriction is not specified and tailwater reductions in excess of 13 vertical feet within a 24 hour period and 7 vertical feet/hour have been documented under normal project operations.

Previous stranding studies on the Cowlitz (Tipping et al 1978, Tipping et al 1979, and Bauersfeld 1978), Skagit (Beck Associates 1989, Phinney 1974, Thompson 1970, and Woodin 1984), and Lewis (Phinney 1974) rivers have documented the existence of fry stranding during controlled flow drawdown experiments. Studies such as these have resulted in the establishment of ramping rate guidelines to minimize fish stranding in systems where river flows are controlled by hydroelectric projects. In addition, Witty and

Thompson (1974) noted that fry stranding does occur in Hell's Canyon of the Snake River, Idaho, even when flow and river level fluctuations are maintained within their Federal Energy Regulatory Commission (FERC) license guidelines.

The Hanford Reach supports the largest of the only two remaining wild fall chinook populations in the Columbia River system. This population of fish is a primary contributor to ocean and freshwater sport and commercial fisheries and in river tribal fisheries. It is also a primary component of an international Pacific Salmon Treaty between the United States and Canada. The possibility of a salmonid fry stranding problem has been well documented for the Hanford Reach. Two studies to document fry stranding on the Hanford Reach (Becker et al 1981, and Page 1976) have shown that stranding of juvenile salmonids and other fishes do occur, but these studies were of short duration and only qualitative in nature. Results of past studies have not been enough to warrant a change in operating procedures at Priest Rapids Dam. Observations in 1988 and as recently as 1995 of chinook fry stranding and entrapment have been made by Washington Department of Fish and Wildlife (WDFW) personnel under normal operating conditions. The implementation and results of a quantitative study are needed to fully assess the degree of stranding and the impact on the fish community and river ecology of the Hanford Reach as well as to develop recommendations for mitigation of losses in place.

The Bonneville Power Administration is directed through the National Marine Fisheries Service Endangered Species Act - Section 7 Biological Opinion on the Reinitiation of Consultation on 1994-1998 Operation of The Federal Columbia River Power System and Juvenile Transportation Program as such: " Beginning in 1995, BPA will evaluate the affect of power peaking operations on juvenile and adult salmon passage and on the river ecology downstream of Bonneville Dam and on the Hanford Reach, downstream of Priest Rapids Dam. Contingent on the results of these evaluations, BPA will develop a plan to decrease power peaking operations from mid-March through mid-December on the lower Snake and Columbia Rivers (Page 162, #11)". In addition, the 1994 Columbia River Basin Fish and Wildlife Program states as a program objective " Beginning in 1995, evaluate alternative ramping rates for flow fluctuations at mainstem Snake and Columbia River dams to constrain reductions and increases in total flow per 24-hour period at these projects." (Page 5-20, 5.1D.4). The proposed work is consistent with both of these objectives.

This is a cooperative study which integrates the past and present work of several agencies including the sharing of personnel, equipment, technical expertise, and technical data. USGS/BRD conducted an evaluation of juvenile fall chinook habitat utilization in the Hanford Reach from 1991 through the present (Rondorf et. al. 1991-1997). This work is ongoing and includes detailed habitat mapping surveys. This survey information is a necessary component of the susceptibility model which is being developed for the Hanford Stranding Evaluation. The BRD lead field supervisor (Loreley Key) has been hired on intermittent status by both BRD and WDFW to continue the survey work for both studies. This minimizes personnel costs for each study while still ensuring competent and compatable data collection. In addition, other staff, surveying/field equipment, and surveying data are shared between the two studies.

Based upon field observations made during the pilot year, exposure to warm water in entrapment zones was the primary cause of direct juvenile chinook mortality related to diel water fluctuations. Delayed mortality and reduced performance/predator susceptibility are other likely effects of thermal stress (C. Coutant, personal communication) but these cannot be measured in the field. Therefore, the BRD Columbia River Research Laboratory has been subcontracted to conduct laboratory tests to determine juvenile fall chinook behavioral and physiological responses to exposure to elevated water temperatures and to thermal shock. BRD was subcontracted for this work due to their technical expertise in the evaluation of acute stressors on physiological and behavioral effects on juvenile salmonids (Mesa 1994).

BRD has also received funding through a COE contract to evaluate predator habitat utilization in the Hanford Reach. This work is scheduled to begin in 1998 and in several aspects overlaps with resident fish work conducted for the Hanford Stranding Evaluation. Therefore, field staff, equipment, and field data will be shared between the BRD study and the Hanford Stranding Evaluation.

An Unsteady Flow Model was developed by PNNL under COE contract for use in modeling dissolved gas transport in the Snake River. PNNL was also subcontracted under the Hanford Stranding Evaluation to develop an Unsteady Flow Model for the Hanford Reach which is a necessary component of the final susceptibility model. This model describes the stage/discharge relationship between the Priest Rapids Project and all points located downstream on the Hanford Reach and is a direct derivation of the Snake River model. The same technical lead (Marshall Richmond) was responsible for the development of both models. In addition, PNNL is currently under BPA contract to develop a Spawning Habitat Model For Snake River Fall Chinook (Geist et., al. 1997 - BPA Project Number 9406900). This work includes GIS mapping and modeling of the Hanford Reach for fall chinook redd distribution relative to the hyporheic flow. The GIS technical lead (Jon Nugent) is a shared employee between PNNL and WDFW and conducts Hanford Reach GIS work for both studies. Other staff, equipment, and technical information are also shared between the two organizations.

The USFWS has been subcontracted by BPA/ODFW (BPA Project Number 8605000) to develop an Instream Flow Incremental Methodology model of the Hanford Reach for sturgeon habitat modeling. This information will also be made available to WDFW for incorporation into the juvenile fall chinook susceptibility model.

Evaluation of the effect of diel water fluctuations on the benthic macro invertebrate community inhabiting the Hanford Reach will be conducted via subcontract by the University of Idaho Department of Fish and Wildlife which has extensive work history conducting similar work on the Snake River under other federal contracts (Bennett et., al. 1990, 1991, 1993, 1997). C.E. Cushing (formerly of PNNL) has been subcontracted to assist in the development, implementation, and analysis of data because of his expertise pertaining to limnological work on the Hanford Reach.

In summary, this research project addresses a clearly identifiable problem and is consistent with the objectives of both the 1994 CRBFWP and the NMFS BIOP. The work draws together technical experts with extensive scientific backgrounds to assist in or conduct various aspects of this study and complements the work of other ongoing studies through collaboration and the sharing of staff, equipment, and data.

b. Proposal objectives.

Objective 1. Evaluate the effect of diel water fluctuations resulting from power peaking activities at Priest Rapids Dam on rearing juvenile fall chinook in the Hanford Reach.

Task A. Continue analysis of data collected during controlled river elevation reduction tests conducted in FY98.

Task B. Conduct laboratory behavioral and physiological tests at USGS/BRD Columbia River Research Laboratory to determine effect (direct and delayed mortality, reduced performance and increased susceptibility to predation) on rearing juvenile fall chinook of exposure to warm water in entrapment areas.

Task C. Collect field data under normal project operations throughout the fall chinook emergence and rearing period (April-June 1999).

Task D. Analyze/report results of field data/tests collected in 1997-1999.

Objective 2. Evaluate the effect of diel water fluctuations resulting from power peaking activities at Priest Rapids Dam on resident fish in the Hanford Reach.

Task A. Continue analysis of data collected during controlled river elevation reduction tests conducted in FY98.

Task B. Collect field data under normal project operations throughout the spring period (April-June 1999).

Task C. Analyze/report results of field data/tests collected in 1997-1999.

Objective 3. Evaluate the effect of diel water fluctuations resulting from power peaking activities at Priest Rapids Dam on the benthic macro invertebrate community in the Hanford Reach (U of I subcontract).

Task A. Conduct field work under normal project operating conditions at identified sampling sites. Use barbeque basket array staggered at incremental flow elevations to sample macro invertebrates exposed to various levels of dessication.

Task B. Conduct laboratory analysis of macro invertebrate samples.

Task C. Determine relationship between water fluctuation and macro invertebrate abundance.

Objective 4. Develop juvenile fall chinook susceptibility model (PNNL subcontract).

Task A. Perform Scanning Hydrographic Operational Airborne Lidar (Light Detection and Ranging) Survey (SHOALS) to obtain detailed bathymetry of the Hanford Reach (Cost share with USGS/BRD, COE performs the survey).

Task B. Integrate Unsteady Flow Model (PNNL), IFIM Model (USFWS), detailed micro-habitat survey information (WDFW/USGS-BRD), and SHOALS data into a dynamic model of the Hanford Reach. Include model fields for juvenile fall chinook emergence timing and rearing periods.

c. Rationale and significance to Regional Programs.

This project serves to address, define, and quantify the frequently observed problem of juvenile fall chinook stranding resulting from power peaking activities at Priest Rapids Dam. This work, as so stated in section "a" is consistent with the objectives of both the FWP and the NMFS-Biological Opinion. In addition, this project draws upon recognized technical experts from multiple agencies currently conducting salmonid related mitigation work in the Columbia basin to assess various objectives specific to this study. This study also represents a comprehensive collaborative effort between fisheries research and management agency programs. These other programs and their relationship to the Hanford Stranding Evaluation are: 1) Smolt Monitoring Program Gas Bubble Trauma Monitoring (BPA funded/WDFW) - Shared staff, equipment, and data, 2) Identification of Spawning, Rearing, and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin (BPA # 9102900/USGS-BRD) - shared staff, equipment, data, and direct cost sharing, 3) Spawning Habitat Model for Snake River Fall Chinook (BPA# 9406900/PNNL) - shared staff, equipment, and data, 4) Evaluation of Predator Habitat in Free Flowing Stretch of Columbia and Snake Rivers (COE contract/USGS-BRD) - shared staff equipment and data, and 5) White Sturgeon, Productivity, Status, and Habitat Requirements (BPA # 8605000/ ODFW-USFWS)- shared data.

This project also serves to assess thermal stress and thermal shock induced direct and delayed juvenile fall chinook mortality and reduced performance ability as related to exposure to warm water and rapid water temperature change. The results of this work can also be applied to better define juvenile fall chinook thermal related mortality at the collection and bypass system at McNary Dam. Direct mortality due to thermal stress and thermal shock have been well documented at this site but delayed mortality rates are completely unknown. Application of such information to other hydroelectric project bypass systems on the Snake and Columbia rivers may be possible as well.

d. Project history

This initial pilot year for this project was 1997 (previous BPA project # 5503800). This was essentially a set up year during which staff were recruited, hired and trained, equipment was purchased, specific field sampling methodology was established, primary juvenile fall chinook production and rearing areas were identified and modeled, the Hanford Reach was stratified into gross habitat categories to aid in the establishment of specific sampling site locations, field data was collected to better define the susceptibility period for fall chinook as well as specific habitat characteristics as related to sampling logistics. Thermal stress induced juvenile fall chinook mortality in entrapment areas was identified as a problem requiring increased focus. Detailed micro-habitat map surveys were conducted in identified entrapment areas in collaboration with USGS/BRD. An Unsteady Flow Model was developed by PNNL for this project. Eleven years of Priest Rapids Dam hourly flow data was analyzed and a controlled river elevation reduction test schedule and protocol were developed for the second year of this evaluation (1998). The feasibility of conducting the benthic evaluation was assessed and a work plan and budget were written. An interim report is currently in draft. The total budget for this work was $174,521.

At present, we are entering the second year (1998) of this three year evaluation.

e. Methods.

Objective 1. Task A. Analysis of data collected during controlled river elevation tests conducted in 1998 will continue during FY99. Hourly discharge information will be modeled to determine specific river elevation reduction histories at designated sampling sites. Entrapment area elevations will be compared to these to define the specific relationship between changes in project discharge and salmonid stranding/entrapment. Data pertaining to fish size will be compiled and analyzed to determine the relationship between stage of life and susceptibility to entrapment. The results of this work is expected to yield a defined relationship between stage of life and susceptibility to entrapment at discharge reductions ranging to 50 kcfs.

Task B. Juvenile fall chinook salmon will be either collected from the Hanford Reach and transported to the Columbia River Research Laboratory. Fish will be divided into groups of treatment and control fish and placed in replicate test tanks (two replicates for each treatment tested). Heat stress treatments will consist of temperature increases over time followed by a relatively abrupt decrease in temperature back to ambient and will be based on scenarios experienced by fish in the wild. To assess the stressful effects of the presence pf predators, some groups will have predators in their tanks, other groups will not. Control fish will be maintained at ambient temperature throughout the experiment. After exposure to the stressor, fish will be held under ambient conditions for 2-4 weeks and mortality will be monitored in all tanks. We will assess differences in mortality by plotting cumulative mortality and comparing the slopes of the lines for each treatment. Chi-squared tests of independence will be used to determine whether total mortality was independent of treatment.

Predation vulnerability experiments

Fish will be divided into groups of treatment and control fish; several weeks prior to the start of predation tests, fish in one group will be marked by removing their adipose fin, whereas the other group will be sham marked. Fish designated as treatments will be subjected to a sublethal heat stress designed to mimic that experienced by fish in the wild. Basically, the heat stress will consist of gradually heating, over the course of several hours, the water flowing into the tank to some predetermined maximum temperature and then rapidly decreasing the temperature back to ambient holding temperature. The rate of warming (i.e., change in temperature/time), maximum temperature, and rate of temperature decrease will be estimated from data collected at the Hanford Reach. Control fish will remain at ambient holding temperature throughout the stressor period. After application of the stressor, equal numbers of treatment and control fish will be rapidly transferred into 19-L buckets filled with water and poured into a predation tank. Predation will be allowed to continue until 50% of the prey are eaten or for 3-6 h, whichever comes first. At the end of each trial, all survivors will be netted, identified as treatment or control fish and measured.

Predation data will be analyzed in a manner identical to that of Mesa (1994). We first will subject all data to heterogeneity chi-square analysis to determine if the individual tests were homogenous (Sokal and Rohlf 1981). Chi-square goodness-of-fit tests will then be used on pooled data to determine if predation was random (i.e., 50:50) on treated versus control fish.

Physiological effects of heat stress

The purpose of these experiments is to document the magnitude and dynamics of selected physiological responses in juvenile fall chinook salmon subjected to a sublethal heat stress. Fish will be obtained as previously described and held in circular tanks receiving water of ambient temperature.

Metabolic cost experiments. Procedures used to assess the metabolic cost of a sublethal heat stress on juvenile fall chinook salmon will be modified after those described by Barton and Schreck (1987). We will use either Blazka (Blazka et al. 1960) or Brett (Brett 1964) type swimming respirometers to estimate oxygen consumption in stressed and unstressed fish.

For details on the operation of these respirometers, see Cech (1990). After acclimation, water velocity in the respirometer will be increased slightly to elicit mild swimming in the fish at about 0.2-0.3 BL/s. During this easy swimming phase, we will subject treatment fish to a heat stress. The stressor will be as described above. Control fish will not receive this heat stressor. Immediately after application of the stressor, fish will be subjected to a swimming challenge of about 0.5 BL/s for 1 h. Dissolved oxygen will be determined electrometrically or titrimetrically. Trials with stressed and unstressed fish will be conducted simultaneously in two respirometers.

After a respirometry trial, fish will be rapidly removed from the respirometer, placed in a lethal dose of tricaine (200 mg/L), and bled into a ammonia-heparinized capillary tube after severance of the caudal peduncle. Metabolites to be assayed from these fish include, but may not be limited to, cortisol, glucose and lactate as indicators of general physiological stress, sodium, chloride, or osmolality as an indicator of osmoregulatory dysfunction, and stress protein synthesis as an indicator of possible cellular damage.

Oxygen consumption of individuals or small groups will be averaged and compared between stressed and unstressed fish using two sample *t*-tests after confirming homogeneity of variance and similarity of mean weights of the two groups of fish. Differences in oxygen consumption between stressed and unstressed fish will be compared to estimates of scope for activity for salmonids from the literature to estimate the percentage of the energy budget required to compensate for the stress. Metabolite data will be compared between stressed and unstressed fish in a manner similar to that described for oxygen consumption.

Physiological stress experiments. We will assess physiological changes in fish subjected to three treatments. Fish designated as controls will be maintained at ambient conditions throughout the experiment. A second group of fish will be designated as heat stressed (HS) and will receive a sublethal heat stress as previously described. A third group of fish will be designated as heat stressed plus predators (HS+P)and will receive the heat stress and have predators present in their tanks. Blood and tissue samples will be collected from subsamples of fish in all groups just prior to the start of the stressor. Samples will be taken from HS and HS+P fish at frequent intervals during application of the stressor and also at several intervals after completion of the stressor. Control fish will be sampled at less frequent, but regular, intervals throughout the experiment.

As indicators of acid-base balance, a small sample of blood will be placed temporarily on ice, centrifuged to obtain the plasma fraction, and stored at -80 C for future analysis. We will remove small fin and muscle samples from fish and place them immediately in liquid nitrogen for stress protein analysis. As an indicator of physiological stress, we will assay plasma cortisol using as enzyme immunoassay modified from procedures described by Munro and Stabenfeldt (1983). To assess carbohydrate metabolism, plasma glucose will be measured using a Sigma diagnostic kit, and osmoregulatory function will be assessed by measuring plasma sodium and chloride using flame photometry and cholridimeter. Tissue samples will be sent to the laboratory of Dr. Lee Weber at the university of Nevada-Reno for stress protein analysis.

For all data, we will calculate mean concentrations, subject them to tests for homogenous variances, and compare among treatments using analysis of variance followed by multiple comparison procedures.

The results of this work can be used to assess some indirect effects of power peaking operations on juvenile fall chinook salmon. These results should prove useful to managers in developing a plan to modify power peaking operations on the Columbia River to minimize impacts on the Hanford Reach. Our data should also increase our understanding of the effects of temperature (in general, as opposed specifically to heat stress) on juvenile fall chinook and may prove useful in assessing temperature problems that occur in other areas. Finally, our results should prove useful to persons involved with development of a bioenergetics model for fall chinook salmon by providing baseline data necessary for the construction of such a model.

Task C. Collection of field data from the Hanford Reach will continue under normal Priest Rapids project operations throughout the emergence and rearing period for fall chinook. This information will be used to augment the database begun in 1997.

Task D. Three years of field data pertaining to juvenile chinook entrapment and modeled hourly flow histories will be compiled and compared to define the relationship between entrapment and discharge fluctuations. This information will be included in the final completion report for the study.

Objective 2. Task A. Analysis of field data pertaining to resident fish species composition, stage of life, and susceptibility to entrapment collected during controlled river elevation reduction tests conducted in FY98 will continue in FY99.

Task B. Collection of field data under normal project operations throughout the spring period (April-June 1999) will continue to augment the database begun in 1997.

Task C. Analysis of data pertaining to resident fish species composition and susceptibility to entrapment under various discharge scenarios will continue during FY99. The results of this work will be included in a final completion report for the study.

Objective 3. Tasks A-C. The purpose of Year 2 (1999) sampling is to examine effects of diel water level fluctuations on the Hanford Reach of the Columbia River on the benthic macro invertebrate fauna on artificial substrata. The success of this project is incumbent on quantifying the water level fluctuations that occur at the test sites. To do this, we would use two pressure sensors to detect the frequency and duration of water level fluctuations. We would place the artificial substrata along a transect at 1 foot intervals from above water levels, assuring that the substrata were exposed to the air, down along the profile of the bottom to a depth of continuous inundation. Also, we would examine the frequency of water level fluctuations that occurred during the test period and compare those with water level fluctuations that have occurred in the past 5 - 10 year period. Comparison of years would assess how representative water level fluctuations were during the test to those in the past several years.

The design of the sampling program for Year 2 (1999) would be based on the findings from Year 1 (1998). The selected artificial substratum would be deployed for the selected duration of exposure for colonization, retrieved, placed in wash tubs to remain wet, and transported to the two selected test sites (Year 1 results). Number of replicates needed to show statistical significance ($P = 0.05$) will be determined from Year

1 sampling. As indicated above, samples would be deployed from highest water level to continuous inundation at 1 foot (0.3m) vertical increments. Following an additional 3 - 5 weeks exposure at the desired depths at the test sites, samples would be retrieved, and processed similarly to those during the initial Year 1 colonization study.

Handling loss from collection and redeployment of the artificial substrata would be quantified by retrieving three substrata and quantifying the number of macro invertebrates present. We would assume that macro invertebrates remaining on the substrata after a 2 day exposure are representative of those that will be exposed to the periodic water level fluctuations. Following the 3 - 5 weeks of exposure to "normal" water level fluctuations, the substrata would be retrieved, organisms removed from the substrata, and preserved. In the laboratory, samples would be separated into midges, caddisfly, and other categories, enumerated, and weighed to dry weight as in Year 1. These data will show the differential effects of varying water depths over the test substrata.

We would statistically determine the significance of the periodic water level fluctuations on macro invertebrate fauna on artificial substrata using two methods. First, mean density and standing crops on the substrata would be calculated by different depth categories: wet-dry categories based on duration of exposure (e.g., 0-25 hours exposure, 25-50 hours, > 50 hours, and continuously inundated). Tests of normality and heteroscedacticity would be conducted and appropriate transformations made to "normalize" the data. Following transformation, analysis of variance would be used with exposure category as treatments using the Statistical Analysis System (SAS1996). The second method would be to use density and standing crop as the dependent variables and duration of exposure to air as the independent variable and conduct regression analysis. The model would test the density (or standing crop) as a function of the duration of exposure to air.

This project will address two null hypotheses:

1. Colonization of artificial substrata is similar between construction bricks and barbecue baskets and that macro invertebrate colonization is not different between 3 and 5 weeks; and 2. Macro invertebrate survival on artificial substrata is similar among various depths in the Columbia River.

This study will examine colonization on two different substrata at three locations and assess survival of macro invertebrates exposed to air by water level fluctuations. We will not make production estimates or quantify effects of diel water level fluctuations on overall population abundance on the Hanford Reach of the Columbia River.

Objective 4. Task A. The COE will be subcontracted to perform a Scanning Hydrographic Operational Airborne Lidar (Light Detection and Ranging) Survey (SHOALS) to obtain detailed bathymetry of the Hanford Reach as needed to complete the susceptibility model (Parsley, 1997). The cost of this work will be shared with USGS/BRD in conjunction with ongoing juvenile fall chinook research.

Task B. The primary components required to complete a GIS based susceptibility model will be obtained and integrated by PNNL. These include: Unsteady Flow Model of the Hanford Reach (created by PNNL for this study), IFIM Model of the Hanford Reach (created by USFWS for white sturgeon research), detailed micro-habitat survey information (collected by WDFW and BRD for this study and BRD juvenile chinook habitat utilization research), and the SHOALS information described under Objective 4, Task A. Data fields for juvenile fall chinook emergence timing and rate of growth will be included in the model.

f. Facilities and equipment.

Field equipment necessary to conduct this work will have been purchased during the first two years of the study. Laboratory work pertaining to thermal tolerance testing will be conducted at the USGS/BRD Columbia River Research Laboratory. Macro invertebrate laboratory work will be conducted at the University of Idaho Department of Fish and Wildlife laboratory. Computer modeling will be conducted at the Pacific Northwest National Laboratories Ecology Group office.

g. References.

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Bauersfeld, Kevin. 1978a. Stranding of Juvenile Salmon by Flow Reductions at Mayfield Dam on The Cowlitz River, 1976. Technical Report No. 36. Washington Department of Fisheries.

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Bennett, D.H., L.K. Dunsmoor, and J.A. Chandler. 1990. Lower Granite Reservoir in water disposal test: Results of the fishery, benthic, and habitat monitoring program - Year 1 (1988). Completion Report. U.S. Army Corps of Engineers, Walla Walla Washington.

Bennett, D.H., J.A. Chandler, and G. Chandler. 1991. Lower Granite Reservoir in water disposal test: Results of the fishery, benthic, and habitat monitoring program - Year 2 (1989). Completion Report. U.S. Army Corps of Engineers, Walla Walla Washington.

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Everhart, W.H., and W.D. Youngs. 1981. Principles of Fishery Science. Second Edition. Comstock Publishing Associates, a division of Cornell University Press. pp 104-108.

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Margalef, R. 1958. Information theory in ecology. General Systems. 3:36-71.

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Parsley, M.J., D.W. Rondorf, and M.E. Hanks. 1997. Remote sensing of fish and their habitats. U.S. Geological Survey-Biological Resources Division. Columbia River Research Laboratory. Cook, Washington.

Phinney, L.A. 1974a. Further Observations on Juvenile Salmon Stranding in The Skagit River, March 1973. Washington Department of Fisheries.

Phinney, L.A. 1974b. Report on the 1972 Study of the Effect of River Flow Fluctuations Below Merwin Dam on Downstream Migrant Salmon. Washington Department of Fisheries. 23 pp.

Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1991 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1992 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1993 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1994 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

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Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1996 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

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Sokal, R.R., and F.J. Rohlf. 1981. Biometry. W.H. Freeman and Co., New York.

Thompson, J.S. 1970a. Skagit River Fry Mortality Study, March 1969. Washington Department of Fisheries. 46 pages.

Tipping, J., P. Buckley, and J. Danielson. 1978. Cowlitz River Steelhead Spawning and Fry Stranding Study, 1977-78. Progress Report. Washington Department of Game.

Tipping, J., S. Springer, P. Buckley, and J. Danielson. 1979. Cowlitz River Steelhead Spawning, Fry Emergence and Stranding, 1977-79, and Adult Life History Study, 1977-79. Washington Department of Game.

Witty, Ken., and K. Thompson. 1974. Fish Stranding Surveys. In: Anatomy of A River. Keith Bayha and Charles Koski eds. pp 113-120. Pacific Northwest River Basins Commission. Vancouver, WA.

Woodin, R. 1984. Evaluation of Salmon Fry Stranding Induced by Fluctuating Hydroelectric Discharge in The Skagit River, 1980-83. Technical Report No. 83. Washington Department of Fisheries.

Zippin, C. 1956. An Evaluation of The Removal Method for Estimating Animal Populations. Biometrics. 12(2): 163-169.

Section 8. Relationships to other projects

As stated earlier in this proposal, this study also represents a comprehensive collaborative effort between fisheries research and management agency programs. These other programs and their relationship to the Hanford Stranding Evaluation are: 1) Smolt Monitoring Program Gas Bubble Trauma Monitoring (BPA funded/WDFW) - Shared staff, equipment, and data, 2) Identification of Spawning, Rearing, and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin (BPA # 9102900/USGS-BRD) - shared staff, equipment, data, and direct cost sharing, 3) Spawning Habitat Model for Snake River Fall Chinook (BPA# 9406900/PNNL) - shared staff, equipment, and data, 4) Evaluation of Predator Habitat in Free Flowing Stretch of Columbia and Snake Rivers (COE contract/USGS-BRD) - shared staff equipment and data, and 5) White Sturgeon, Productivity, Status, and Habitat Requirements (BPA # 8605000/ ODFW-USFWS)- shared data.

Section 9. Key personnel

Name: Paul G. Wagner

Title: Project Leader

Degrees Earned: B.S. Fisheries Management. University of Washington. Seattle. 1983.
Current Employer: Washington Department of Fish and Wildlife.

Relationship to Project: Paul Wagner is the project leader of this evaluation. He is responsible for overall development of study design and budget management, study implementation, oversight of subcontracted parties, analysis of data, supervision of WDFW staff, interim and final report writing, and coordination with collaborating agencies and affected parties.

Current Responsibilities: Same as above.

Employment History: Paul Wagner began employment with the Washington Department of Fish and Wildlife in 1983. He began work for WDFW under federal contracts in 1987 at McNary Dam as the Fish Transportation Oversight Team (FTOT) representative. He has extensive experience in juvenile fall chinook thermal mortality assessment at McNary Dam and initiated the thermal profiling procedure currently in effect at that project. In 1990 he became the McNary Smolt Monitoring Program supervisor and began conducting independent and cooperative research projects under federal contracts that same year. Most noteworthy research included the 1990 and 1991 evaluations of adult fallback at McNary Dam. In 1992, he initiated the first PIT tagging project for wild upriver bright fall chinook on the Hanford Reach which was later incorporated into the Smolt Monitoring Program. He has been a member of the Vernita Bar Monitoring Team for determination of critical flows for the protection of pre-emergent fall chinook in the Hanford Reach since 1987. Currently under federal contracts, he acts as the WDFW project leader in juvenile passage related research in the Columbia basin. He also supervises Smolt Monitoring Program, Gas Bubble Trauma Monitoring, and Transportation/Bypass System Quality Control at McNary, Ice Harbor, and Lower Monumental Dams.

Publications:

Wagner, P. 1990 McNary Dam Smolt Monitoring Program. Annual Report. State of Washington. Department of Fisheries. Habitat Management Division. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87-127. Contract Number DE-FC79-88BP38906. 20 pages.

Wagner, P. 1990 Evaluation of The Use of The McNary Bypass System To Divert Adult Fallbacks Away From Turbine Intakes. State of Washington. Department of Fisheries. Habitat Management Division. Report to United States Army Corps of Engineers. Modification to Contract Number DACW-68-82-C-0077. Task Order Number 9. 72 pages.

Wagner, P. 1991 McNary Dam Smolt Monitoring Program. Annual Report. State of Washington. Department of Fisheries. Habitat Management Division. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87-127. Contract Number DE-FC79-88BP38906. 40 pages.

Wagner P., and T. Hillson. 1991 Evaluation of Adult Fallback Through The McNary Dam Juvenile Bypass System. State of Washington. Department of Fisheries. Habitat Management Division. Report to United States Army Corps of Engineers. Contract Number DACW-68-82-C-0077. Task Order Number 10. 79 pages.

Nelson W., D. Rondorf, and P. Wagner. Subyearling Chinook Salmon Marking at McNary Dam to Estimate Adult Contribution. 1992. United States Fish and Wildlife Service. Columbia River Research Laboratory. Washington Department of Fisheries. Habitat Management Division. Annual Report to The Bonneville Power Administration. 13 pages.

Name: Dennis W. Rondorf

Title: Fishery Research Biologist

Degrees Earned: M.S. Oceanography and Limnology, University of Wisconsin, Madison, 1981
B.S. Wildlife Management, University of Minnesota, St. Paul, 1972

Relationship to Project: Dennis Rondorf has been the project leader for USGS/BRD juvenile fall chinook habitat utilization assessment in the Hanford Reach since 1991. This work includes juvenile chinook micro-habitat map surveying which is a necessary component of the susceptibility model being developed for the Hanford Stranding Evaluation. WDFW and USGS/BRD are working in collaboration through sharing of staff and equipment to collect this survey information. The collected data will be used by both studies. In addition, cost sharing between USGS/BRD and WDFW will occur to conduct a Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) of the Hanford Reach to obtain detailed bathymetric data. Mr. Rondorf serves as the technical lead for this work. The bathymetric data is again a necessary component of the susceptibility model and the collected data will be shared between the two BPA funded projects (9102900 and 9701400).

Current Employment and Responsibilities: D.W. Rondorf serves as a Fishery Research Biologist and Section Leader for the Anadromous Fish Ecology section at the Columbia River Research Laboratory, Biological Resources Division, U.S. Geological Survey, Cook, Washington. Current areas of research include the behavior and ecology of Snake River wild and hatchery fall chinook salmon, the distribution of smolts and relation to gas supersaturation in the main stem Columbia River, and behavior of smolts to evaluate a prototype surface collector at Lower Granite Dam, Washington. In recent years, D.W. Rondorf has lead research teams using radio telemetry, geographic information systems (GIS), global positioning systems (GPS), remotely operated underwater vehicles (ROV), hydro acoustic fish stock assessment systems, and acoustic Doppler current profilers (ADCP) as research tools. Between 1979 and 1997, D.W. Rondorf was employed by the research division of the U.S. Fish and Wildlife Service and the National Biological Service to conduct research on juvenile salmon in the Columbia River basin including identification of spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin with much of the work conducted in the Hanford Reach.

Publications:

Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1992

Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1993 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

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Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1995 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Parsley, M.J., D.W. Rondorf, and M.E. Hanks. 1998. Remote sensing of fish and their habitats. Proceedings of instream and environmental flows symposium-technology and policy issues. (*In Press*) North American Lake Management Society and others, Denver, Colorado.

Name: Loreley O. Key
Title: Fisheries Biologist
Current Employer: Washington Dept of Fish and Wildlife
US Geological Survey Columbia River Research Laboratory

Degrees Earned: M.S. Biology (Fisheries Emphasis) 1991
Eastern Washington University

B.S. Zoology 1987
Eastern Washington University

Relationship to Project: Loreley Key was the lead USGS/BRD field supervisor conducting juvenile fall chinook habitat utilization research under BPA contract from 1991 through 1996. This work included juvenile chinook micro-habitat map surveys. Loreley has extensive field experience in the Hanford Reach conducting juvenile chinook research and is the technical lead for the habitat map surveys being conducted under the Hanford Stranding Evaluation.

Current Responsibilities: Currently, Loreley works for both WDFW and USGS/BRD and is shared between the two BPA funded projects (9701400 and 9102900). Her current responsibilities include report writing (9102900) and acting as the lead field supervisor and micro-habitat map survey technical expert (9701400).

Previous Employers: 1997 Washington Dept of Fish and Wildlife
1991-1996 US Geological Survey Columbia River Research Laboratory

1991 Washington Dept of Wildlife

Publications:

Key, L.O., R. Garland, and K. Kappenman. 1996. Near shore Habitat Use By Subyearling Chinook Salmon and Non-Native Piscivores in the Columbia River. Pages 64-79 in Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1994 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Key, L.O., R. Garland, and E.E. Kofoot. 1994. Near shore habitat use by subyearling chinook salmon in the Columbia and Snake Rivers. Pages 74-107 in Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1993 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Key, L.O., R. Garland, J.A. Jackson, C.R. Sprague, and E.E. Kofoot. 1994. Near shore habitat use by subyearling chinook salmon in the Columbia and Snake Rivers. Pages 120-150 in Rondorf, D.W. and K.F. Tiffan, editors. Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin. 1992 Annual Report to Bonneville Power Administration. Contract DE-A179-91BP21708, Portland, Oregon.

Co-Author, Assessment of Fisheries Improvement Opportunities on the Pend Oreille River. 1989 and 1991 Annual Reports to Bonneville Power Administration, Contract DE-179-88BP39339.

Name: Matthew G. Mesa

Title: Research Fishery Biologist

Current Employer: U.S. Geological Survey, Biological Resources Division
Columbia River Research Lab, Cook, WA

Degrees Earned: Advancement to candidacy for Ph.D.
Oregon State University, 1995

M.S., Fisheries
Oregon State University, 1989

B.S., Natural Resource Management
California Polytechnic State University, 1984
at San Luis Obispo

Relationship to Project: Matt Mesa will act as the project leader evaluating thermal tolerance of juvenile fall chinook in relationship to entrapment and exposure to warm water on the Hanford Reach. He is responsible for literature review, budget and work plan development including laboratory physiological and behavioral testing methodology, analysis of data, and reporting. He is responsible for overall supervision of thermal tolerance tests conducted at the USGS/BRD Columbia River Research Laboratory as related to the Hanford Stranding Evaluation.

Current Responsibilities: Literature review, budget and work plan development specific to thermal tolerance testing of juvenile upriver bright fall chinook.

Previous Employers: 1991-Present Research Fishery Biologist, U.S. Geological Survey, Biological Resources Division, Columbia River Research Lab, Cook, WA

1989-1991 Fishery Biologist, U.S. Fish and Wildlife Service, Seattle-NFRC, Columbia River Field Station, Cook, WA

1986-1989 Fishery Biologist/CEA Appointee, Seattle-NFRC, Oregon Cooperative Fisheries Research Unit, Oregon State University, Corvallis, OR

1984-1986 Fishery Biologist, U.S. Fish and Wildlife Service, Seattle-NFRC, Columbia River Field Station, Cook, WA

Expertise: Team leader on research projects addressing the effects of dissolved gas supersaturation on juvenile salmonids and evaluating predator-prey relations in Columbia River fishes. Areas of expertise include predator-prey interactions in fishes, fish behavior and performance, and general and stress physiology of fishes.

Publications:

Mesa, M.G. and C.B. Schreck. 1989. Electro fishing mark- recapture and depletion methodologies evoke behavioral and physiological changes in cutthroat trout. Transactions of the American Fisheries Society 118:644-658.

Mesa, M.G. 1991. Variation in feeding, aggression, and position choice between hatchery and wild cutthroat trout in an artificial stream. Transactions of the American Fisheries Society 120:723-727.

Mesa, M.G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile chinook salmon. Transactions of the American fisheries Society 123:786-793.

Mesa, M.G., T.P. Poe, D.M. Gadomski, and J.H. Petersen. 1994. Are all prey created equal? A review and synthesis of differential predation on prey in substandard condition. Journal of Fish Biology 45 (Supplement A):81-96.

Mesa, M.G., T.P. Poe, A.G. Maule, and C.B. Schreck. *In press*. Vulnerability to predation and physiological stress responses in juvenile chinook salmon experimentally infected with *Renibacterium salmoninarum*. Canadian Journal of Fisheries and Aquatic Sciences.

Name: John J. Nugent
Title: Fish Biologist
Current Employer: Pacific States Marine Fisheries Commission
Supervised by Battelle, Pacific Northwest National Laboratory
Supervised by Washington Department of Fish and Wildlife

Degrees Earned: M.S., Environmental Studies
University of Montana, Missoula, 1995

B.S., Wildlife Biology
University of Montana, Missoula, 1994
Minor - Botany
Minor - Zoology

B.S., Geology
University of Georgia, Athens, 1985

Relationship to Project: John Nugent has conducted Geographic Information System work for the Pacific Northwest National Laboratories since 1991. He was hired through the Pacific States Marine Fisheries Commission as a shared employee for the Hanford Stranding Evaluation (Project # 9701400) and the PNNL spawning habitat model for Snake River fall chinook project (Project #9406900). John maintains his office in the PNNL complex and serves as the technical GIS expert for both projects.
Current Responsibilities: John currently conducts GIS mapping work for habitat categorization, juvenile chinook production and rearing area identification, as well as flow modeling work for the Hanford Stranding Evaluation (Project # 9701400). He also provides GIS expertise for the PNNL Ecology Group BPA funded work (Project #9406900).

Previous Employers: 1991 to Present Battelle, Pacific Northwest National Laboratory 1997 to Present Pacific States Marine Fisheries Commission

Expertise: Worked on a variety of ecological research and monitoring projects in southeastern Washington primarily on the U.S. Department of Energy's Hanford Site and the U.S. Army's Yakima Training Center. Several projects involved the use of Geo-graphic Information Systems to model habitat use by species of concern (ferruginous, Swainson's, red-tailed hawks, sage grouse, sage sparrows), determine impacts of human activities (military training exercises, environmental cleanup activities), and identify areas for mitigation and restoration (sagebrush restoration). Other projects included wildlife surveys (nesting raptors, bald eagles, deer and elk) and vegetation mapping. Also provided technical support on the development of a biological resource management plan, underwater video surveys of fall chinook salmon spawning sites on lower Snake River, and characterization of water velocities at fall chinook salmon spawning sites using an Acoustic Doppler Current Profiler. Some projects required the use of remotely sensed data, Global Positioning Systems, trapping and handling of animals, and radiotelemetry.

Publications:

Nugent, J. J. 1995. Nest-site and habitat selection of Buteo species in southeastern Washington and the use of geographic information systems to model nest habitat. M.S. thesis, University of Montana, Missoula, Montana.

Bromenshenk, J. J., R. C. Cronn, and J. J. Nugent. 1996. Monitoring fluoride with honey bees in the upper Snake River Plain of Idaho. J. Environ. Qual. 25:868-877.

Cadwell, L. L., M. A. Simmons, J. J. Nugent, and V. I. Cullinan. 1996. Sage grouse habitat on the Yakima Training Center: part II habitat modeling (draft). Pacific Northwest National Laboratory, Richland, Washington.

Watson, V., J. Rokosch, J. J. Nugent, S. Manley, and J. Moore. 1993. Copper and zinc in aquatic insects in the upper Clark Fork River. Proc. Mont. Acad. Sci. 53:25-32.

Downs, J. L., W. H. Rickard, C. A. Brandt, L. L. Cadwell, C. E. Cushing, D. R. Geist, R. M. Mazaika, D. A. Neitzel, L. E. Rogers, M. R. Sackschewsky, and J. J. Nugent. 1993. Habitat types on the Hanford Site: wildlife and plant species of concern. PNNL-8942, Pacific Northwest Laboratory, Richland, Washington.

Name: Marshall C. Richmond
Title: Senior Research Engineer
Hydrology Group
Environmental Technology Division
Battelle, Pacific Northwest Laboratories
Current Employer: Battelle, Pacific Northwest National Laboratories

Degrees Earned: Ph.D., Civil and Environmental Engineering
University of Iowa, 1987

M.S., Civil and Environmental Engineering
Washington State University, 1983

B.S., Civil and Environmental Engineering
Washington State University, 1982

Professional Registration: Engineer-In-Training, No. 10729, Washington, July 1982

Relationship to Project: Marshall Richmond is the senior research engineer with PNNL and is a technical expert in the area of flow dynamics and river system modeling. He was the technical lead in the development of the unsteady flow model used for modeling total dissolve gas movement on the Snake River (under COE contract) and the unsteady flow model describing Columbia River flow dynamics for the Hanford Reach used in the Hanford Stranding Evaluation (Project # 9701400).

Current Responsibilities: Modification to the unsteady flow model of the Hanford Reach to include water temperature and total dissolved gas. Integration of unsteady flow model and other components into final susceptibility model.

Expertise: Dr. Richmond rejoined Battelle Pacific Northwest Laboratories in 1994 as a Senior Research Engineer in the Hydrology Group. His professional experience includes basic and applied research, university teaching, and project management. His principal areas of expertise are in the development and application of computational models of contaminant transport and fate in environmental systems, physical modeling of hydraulic structures, fisheries engineering, sediment transport modeling, and turbulence modeling in computational fluid dynamics.

Projects:

Unsteady Flow and Dissolved Gas Transport Modeling Surface Runoff and Contaminant Transport in Watersheds Hydraulic and Contaminant Transport Modeling of Rivers.

Publications:

Walters, W.H., M.C. Richmond, and B.A. Gilmore. 1996. Restruction of Radioactive Contamination in the Columbia River. Health Physics, bol. 71, No. 4, pp. 556-567.

Paluszkiewicz, T., L.F. Hibler, M.C. Richmond, D.J. Bradley, and S.A. Thomas. 1996. Modeling the Potential Radionuclide Transport by the Ob and Yenisey Rivers to the Kara Sea. Accepted for publication in Marine Pollution Bulletin.

Richmond, M.C. 1995. Strategies for Modeling Dissolved Gas Transport in the Columbia and Snake Rivers. U.S. Army Corps of Engineers Gas Abatement Study Modeling Workshop, Newport, OR, February 1-2, 1995.

Richmond, M.C., M.S. Wigmosta, and W.A. Perkins. 1998. Lower Snake River Hydraulics and Sediment Transport, Pacific Northwest National Laboratory, Richland, Washington.

Walters, W.H., M.C. Richmond, and B.G. Gilmore. 1993. Reconstruction of Radionuclide Concentrations in the Columbia River from Hanford, Washington to Portland, Oregon for January 1950-January 1971. Hanford Environmental Dose Reconstruction Project. PNWD-2225 HEDR. Battelle Pacific Northwest Laboratories, Richland, Washington.

Name: David R. Geist
Title: Senior Research Scientist
Ecology Group
Battelle, Pacific Northwest Laboratories
Current Employer: Battelle, Pacific Northwest Laboratories

Degrees Earned: Ph.D., Biology (In Progress)
Oregon State University

M.S., Biology
Eastern Washington University, 1987

B.S., Biology
Eastern Washington University, 1984

Relationship to Project: David Geist is the project leader for PNNL for all collaborative or subcontracted work pertaining to the Hanford Stranding Evaluation. He, in conjunction with Marshall Richmond, will be principally responsible for finalization of the unsteady flow model and integration of necessary data from outside sources into the final susceptibility model.

Current Responsibilities: Subcontract oversight to ensure that critical deadlines are met within budgetary constraints, unsteady flow model development and user support, initial scooping of susceptibility model development, and coordination with other agencies for data integration needed for the development of the susceptibility model.
Previous Employers: 1991- 1998 Battelle Pacific Northwest National Laboratory

Expertise: Mr. Geist is a Senior Research Scientist in the Ecology Group at Battelle, Pacific Northwest National Laboratory. He has been with Battelle since 1991 and has extensive experience and expertise in the ecology of Pacific Northwest fishes, especially fall chinook salmon in he Hanford Reach. Mr. Geist is presently completing a Ph.D. in fisheries at Oregon State University. His research involves developing and testing a conceptual spawning habitat model that describes the importance of landscape processes in determining utilization of spawning areas by fall chinook salmon.

Projects:

Lead scientist and project manager for several projects addressing environmental monitoring and technology applications, including investigating habitat utilization, bioenergetics, and migration behavior of fall chinook salmon in the Columbia River.

Study ground-water/surface-water interactions and contaminant movement in salmon spawning areas in the Hanford Reach.

Modeling impacts of hydro power system operations on resident fish in the Upper Columbia River, including Lake Roosevelt and participation in planning and evaluation activities of salmon supplementation in the Yakima and Klickitat Rivers.

Publications:

Geist, D.R. 1995. The Hanford Reach: What Do We Stand to Lose? Illahe11:130-141.

Geist, D.R., M.C. Joy, D.R.Lee, and T. Gonser. In press. A Method for Installing Piezometers in Large cobble Bed Rivers. Ground Water Monitoring and Remediation.

Geist, D.R. and D.D. Dauble. In press. Redd Site Selection and Spawning Habitat Use by Fall Chinook Salmon: The Importance of Geomorphic Features in Large Rivers. Environmental Management.

Geist, D.R., D.D. Dauble, and R.H. Visser. 1997. The development of a spawning habitat model to aid in recovery plans for Snake River fall chinook salmon. Fiscal Year 1995 and 1996 Progress Report to the Bonneville Power Administration, Portland, Oregon.

Geist, D.R., L.W. Vail, and D.J. Epstein. 1996. Analysis of Potential Impacts to Resident Fish from Columbia River System Operation Alternatives. Environmental Management 20:275-288.

Name: David H. Bennett

Title: Professor, Department of Fish and Wildlife Resources
University of Idaho, Moscow

Current Employer: University of Idaho, Moscow

Degrees Earned: Ph.D., Wildlife Biology (Fisheries Science Option)
Virginia Polytechnic Institute & State University, 1976

M.S., Fish Management
University of Connecticut, 1968

B.S., Wildlife Management
University of Connecticut, 1964

Relationship to Project: David Bennett is the project leader for the evaluation of the effect of diel water fluctuations on the benthic macoinvertebrate community of the Hanford Reach. Dr. Bennett and the University of Idaho were specifically subcontracted to conduct this work under the Hanford Stranding Evaluation because of his extensive experience and expertise conducting benthic macro invertebrate research relative to hydroelectric project operations on the Snake River system under COE contracts.

Current Responsibilities: Dr. Bennett is currently responsible for benthic macro invertebrate study plan development, implementation, and analysis including establishment of objectives, sample site selection and sampling methodology, methods of laboratory and statistical analysis, budget formulation, and supervision of field and laboratory staff.

Previous Employers: 1975- Present University of Idaho, Moscow

Publications:

Dupont, J.S. and D.H. Bennett. 1997. Effects of water level fluctuations on fishes in the Pend Oreille River Idaho. Submitted for publication Transactions of the American Fisheries Society.

Bennett, D.H., L.K. Dunsmoor, and J.A. Chandler. 1990. Lower Granite Reservoir in water disposal test: Results of the fishery, benthic, and habitat monitoring program - Year 1 (1988). Completion Report. U.S. Army Corps of Engineers, Walla Walla Washington.

Bennett, D.H., J.A. Chandler, and G. Chandler. 1991. Lower Granite Reservoir in water disposal test: Results of the fishery, benthic, and habitat monitoring program - Year 2 (1989). Completion Report. U.S. Army Corps of Engineers, Walla Walla Washington.

Bennett, D.H., and T. Nightengale. 1997. Comparison and dynamics of the benthic macro invertebrate communities of Lower Granite, Little Goose, and Lower Monumental reservoirs. Draft Completion Report. U.S. Army Corps of Engineers, Walla Walla Washington.

Bennett, D.H. 1993. Comparison and dynamics of the benthic community of Lower Granite, Little Goose, and Lower Monumental reservoirs. Completion Report. U.S. Army Corps of Engineers, Walla Walla Washington.

Name: Colbert E. Cushing

Title: Private Consultant

Current Employer: Streamside Programs Consultants

Degrees Earned: Ph.D., Biology (Limnology)

University of Saskatchewan, 1961

M.S., Zoology (Limnology)
Colorado State University, 1954

B.S., Fisheries Management
Colorado State University, 1952

Relationship to Project: Colbert Cushing is internationally recognized for his expertise in benthic limnology. Dr. Cushing retired from PNNL after 35 years of employment with much of his work centered on the Hanford Reach. Because of his technical expertise and familiarity with the study area, he has been subcontracted to act as a technical advisor to Dr. Dave Bennett and to assist in study plan development, including sample site selection, sampling methodology determination, interpretation of results, drafting and review of the final report.

Current Responsibilities: Dr. Cushing is currently responsible for assisting Dr. Bennett in study plan development including sample site selection, sampling methodology, and providing technical support specific to benthic work in the Hanford Reach.

Previous Employers: 1961- 1996 Battelle Pacific Northwest National Laboratory
Senior Research Scientist, Ecology Group

Expertise: Dr. Cushing's major research interests are in the fields of stream ecology, mineral cycling, and radio ecology. His major research interests have been focused on theoretical ecological studies of lotic ecosystems. The emphasis of his research in the Hanford area includes Rattlesnake Springs, McNary Reservoir, and Gable Mountain Pond. These studies have included a detailed examination of the dynamics of stream ecosystems in several biomes in the U.S., with particular emphasis on the Salmon River, Idaho and its tributaries (co-Pl, NSF River Continuum Project); the impact of the Mt. St. Helens eruption on stream ecosystems at varying distances from the volcano and various aspects of the ecology of cold desert spring-streams, including primary and secondary production, organic carbon budgets, allochthonous organic matter input, insect food habits, recolonization following flash-floods, and carbon sources for insects.

Publications: Cushing, C.E. 1993a. Impact of experimental dewatering of Lower Granite and Little Goose reservoirs on benthic invertebrates naad macrophytes. Completion Report. PNNL-8807. Pacific Northwest Laboratory, Richland, Washington.

Cushing, C.E. 1993b. Aquatic studies at the 100-HR-3 and 100-NR-1 Operable Units. Pacific Northwest Laboratories, Richland, Washington.

Watson, D.G., C.E. Cushing, and C.C. Coutant. 1967. Environmental effects of extended reactor shutdown - fish. IN: The environmental effects of an extended

Hanford Plant shutdown. BNWL-CC-1056 (Classified). Battelle Memorial Institute, Pacific Northwest Laboratory, pp 71-75. (Unclassified biological data appears in Publication No. 17).

Cushing, C.E., D.G. Watson, J.L. Gurtisen, and A.J. Scott. 1981. Decrease of radio nuclides in Columbia River biota following closure of Hanford reactors. Health Physics 41:59-67.

Cushing, C.E., Jr. 1979. Trace elements in Columbia River food webb. Northwest Sci. 53:118-125.

Section 10. Information/technology transfer

Specific data derived from this work will be exchanged among all collaborating agencies and available upon request to other groups. A completion report will be distributed upon request. Internet access to the Unsteady Flow and Susceptibility models can be made available.